Analysis of Olfaction after Bilateral Nasoseptal Rescue Flap Transsphenoidal Approach with Olfactory Mucosal Preservation

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Abstract

Objective. To ascertain the impact of septal olfactory strip preservation and bilateral rescue flap elevation on the incidence of olfactory dysfunction.


Setting. Providence Saint John’s Health Center and John Wayne Cancer Institute.

Subjects and Methods. The incidences of postoperative epistaxis, hyposmia, and anosmia were analyzed using the Brief Smell Identification Test (B-SIT), which was completed in 110 of the 165 patients.

Results. Seventy-eight patients required extended approaches. Bilateral nasoseptal rescue flaps were elevated in 144 patients (87.3%) and pedicled nasoseptal or middle turbinate flaps in 21 patients (12.7%). The neurovascular pedicles were preserved in all patients, and there were no episodes of postoperative arterial epistaxis. Normal olfaction was noted in 95 patients (86%), with new hyposmia noted in 5 patients (5.5%). Within the rescue flap cohort, new hyposmia occurred in 6.3% (P < .01) of patients, balanced by improvement of olfaction in 43% of patients with preoperative dysfunction (overall pre- and postoperative olfactory function: 85% vs 86%). Patients with pedicled nasoseptal flaps did not have new hyposmia, with a net improvement of olfaction (71% vs 86%, P = .07). No patients experienced new anosmia. There was no difference between flap type within either subgroup.

Conclusions. Superior olfactory strip preservation during elevation of reconstructive flaps preserves olfactory function and maintains adequate surgical exposure. In addition, rescue flaps have significantly diminished the rate of arterial postoperative epistaxis while maintaining the ability to harvest nasoseptal flaps for future reconstruction.

Keywords

endonasal approach, anosmia, hyposmia, cerebrospinal fluid leak, endonasal endoscopic surgery, epistaxis, nasoseptal flap, olfaction, pituitary adenoma

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Preservation of olfactory function following endonasal skull base surgery remains a primary objective in developing minimally invasive approaches. However, most studies rely on subjective reports of a patient’s perception of their olfactory function. This is problematic, as large population cohorts of smell function confirm that subjective patient impressions do not correlate with objective olfactory function.

Anatomic studies have located the endonasal olfactory epithelium to be in the posterior superior septal mucosa, herein termed the septal olfactory strip (SOS), and in the lateral nasal wall turbinate mucosa involving the entire length of the superior and/or supreme turbinate and the
posterior superior aspect of the middle turbinate. SOS and turbinate trauma or sacrifice may often result in varying degrees of postoperative hyposmia or anosmia.1-3 Although generally underreported, this iatrogenic loss of olfaction and associated taste dysfunction can significantly affect patients’ quality of life.4-6 In the initial description of the nasoseptal flap (NSF), the authors recognized this potential postoperative complication and advised to incise the mucosa 1 to 2 cm below the superior most aspect of the septum to best preserve the olfactory epithelium in this region when creating the posterior superior limb of the flap.7-9

Mucosal destruction and NSF elevation may also result in significant postoperative nasal crusting and discharge. Preserving olfactory function while ensuring adequate surgical exposure and instrument maneuverability is the goal of this surgical technique. In addition, preserving the posterior nasosseptal artery may decrease the incidence of postoperative posterior epistaxis.10-14

The endonasal endoscopic approach has been increasingly used for most pathologies of the median anterior skull base. Although effective for safe tumor removal, recognized complications of this technique include postoperative cerebrospinal fluid (CSF) leaks, life-threatening epistaxis secondary to transection of the sphenopalatine arterial branches, prolonged nasal crusting with chronic bacterial colonization, endonasal synechiae causing nasal obstruction, and olfactory dysfunction.8-13 The use of the Hadad-Bassagasteguy NSF has considerably reduced postoperative CSF leak rates in extended approaches associated with large dural openings (grade 3 CSF leak: Esposito-Kelly Classification; Table 1).15 However, an NSF is rarely necessary for smaller dural defects (grade 1 and 2 CSF leaks; Table 1) that are often encountered during the removal of sellar lesions such as pituitary adenomas and Rathke cleft cysts (RCCs).7,8,15

In traditional endonasal transsphenoidal approaches, typically 1 or both of the posterior septal artery pedicles are sacrificed while performing the standard posterior septectomy and sphenoidotomy (if an NSF is not elevated at the start of the procedure). This eliminates the NSF as a potential reconstruction option if a large CSF leak is encountered or if an extensive reconstruction is needed during future procedures.7,8 Conversely, elevation of the NSF at the beginning of the procedure could result in excessive utilization in cases in which it is difficult to predict the extent of the exposure. The unilateral rescue flap technique as first described by Rivera-Serrano et al16 in cadaveric dissections circumvents this problem by preserving the posterior nasoseptal arterial pedicle on one side without obstructing access to the rostrum of the sphenoid, allowing for the elevation of a full NSF should it become necessary. This study retrospectively analyzes preoperative and postoperative olfactory data to ascertain the effectiveness of the SOS sparing bilateral rescue flap technique.

**Clinical Materials and Methods**

Following Providence Health System Institutional Review Board approval, patients who underwent an endonasal endoscopic approach for tumor or cyst removal at Providence Saint John’s Healthcare Center were enrolled in the study. Olfaction data were collected retrospectively, from February 2012 and August 2014, although chart review was performed retrospectively. All patients underwent an incisional technique, mucosal sparing with bilateral preservation of the SOS and the nasoseptal vascular pedicles (Figures 1, 2, and 3). During the procedure, 17 patients had a planned nasoseptal or middle turbinate flap, and 4 patients were converted from rescue flaps to NSFs. All patients had a preoperative Brief Smell Identification Test (B-SIT; Sensonics, Inc, Haddon Heights, New Jersey), also known as the Cross-Cultural Smell Identification Test (CC-SIT). In the postoperative period, a repeat B-SIT study was done as early as 8 weeks postoperatively or when the nasal cavity was inspected endoscopically demonstrating normal healing. Fifty-five patients did not complete the olfactory study but were included in the postoperative analysis to follow associated complications, notably postoperative epistaxis.

**Patient Selection and Surgical Technique**

Candidates for a bilateral nasal mucosal incisional technique included patients who underwent first-time surgery for a pituitary adenoma or RCC as well as for other intrasellar and/or primary extradural tumors. A planned vascularized NSF was routinely used in extended skull base approaches in which large dural defects are created. Patients who had undergone sinus or transsphenoidal surgery in the past were assessed intraoperatively for surgical technique. Patients undergoing revision surgery in which one of the vascular

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**Table 1. Cerebrospinal Fluid (CSF) Leak Grading System.**

<table>
<thead>
<tr>
<th>Leak Grade</th>
<th>Description of CSF Leak</th>
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<tbody>
<tr>
<td>Grade 0</td>
<td>Absence of CSF leak, confirmed by Valsalva maneuver</td>
</tr>
<tr>
<td>Grade 1</td>
<td>Small “weeping” leak, confirmed by Valsalva maneuver, without obvious or with only small diaphragmatic defect</td>
</tr>
<tr>
<td>Grade 2</td>
<td>Moderate cerebrospinal fluid leak, with obvious diaphragmatic defect</td>
</tr>
<tr>
<td>Grade 3</td>
<td>Large cerebrospinal fluid leak, typically created as part of extended transsphenoidal approach through the supradiaphragmatic or clival dura for tumor access</td>
</tr>
</tbody>
</table>


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**Figures 1, 2, and 3**
pedicles has been previously obliterated or transected were not included in the study.

The endonasal approach and transsphenoidal operation were performed as previously described. Notably, the endonasal approach was performed via a binostril, fully endoscopic technique. Bilateral rescue flaps were elevated to preserve the SOS and the sphenopalatine artery and its nasoseptal branches. These flaps are elevated using the incisional technique as previously described, which avoids resection of the nasal cavity mucosa and preserves the superior olfactory strip and sphenopalatine artery pedicle. The incision is started at the midpoint between the sphenoid ostium and the sphenopalatine pedicle and extended along the nasal septum paralleling the middle turbinate and terminating at the anterior margin of the middle turbinate (Figure 2). A short, relaxing incision is made along the lateral margin as well. Submucosal dissection is then performed, elevating the superior olfactory strips superiorly and depressing the sphenopalatine pedicle and rescue flaps inferiorly. The pedicles are protected with a cotton sponge to prevent inadvertent injury and to retract them as low as possible for adequate sphenoid sinus exposure.

The superior and middle turbinates were preserved in all rescue flap cases. The nasoseptal pedicled flap was elevated in anticipation of a dural opening for typical pathology (meningioma, craniopharyngioma). In some cases, the rescue flaps were converted to NSFs after tumor resection when the dural opening had been clearly assessed to need such a repair.

**Patient Follow-up**

Outpatient nasal debridements were typically performed on or around postoperative day 10 and then twice more at 2-week intervals until the nasal cavity was completely healed and free of crusting (Figure 4). Objective olfactory analysis was measured preoperatively and postoperatively at a minimum of 2 months after surgery if the mucosal healing was complete as determined by endoscopic inspection. The patients were blinded to the olfaction test results. Olfactory testing was achieved by using the University of Pennsylvania Brief Smell Identification Test (Sensonics, Inc).

**Statistical Analysis**

Statistical analysis was performed using SPSS software (v13.0, LEAD Technologies, Inc, Charlotte, North Carolina). Chi-squared analysis was performed for subgroup frequency analysis. \( P < .05 \) was considered statistically significant.

**Results**

A total of 165 patients who underwent endoscopic endonasal transsphenoidal resection of sellar or parasellar lesions from February 2012 through August 2014 (mean age 50 years; range, 17-91 years) were enrolled in the study. Histopathological diagnoses included 122 pituitary adenomas, 16 RCC, 8 meningiomas, 7 craniopharyngiomas, 3 sellar arachnoid cysts, 3 chordomas, 2 schwannomas, and 4 other parasellar lesions. One hundred ten (66%) completed
the olfactory study, and 55 patients (33%) were unable to complete the smell study postoperatively because of follow-up or logistical reasons. Similarly, only 15 of 21 patients who underwent reconstruction with a pedicled flap completed the olfactory study. Seventeen of 21 patients had planned vascularized flap reconstructions, and the remaining 4 patients had rescue flaps that required intraoperative conversions to a NSF (Table 2).

The study group was divided into primary/revision and standard/extended transsphenoidal approaches (Table 3). In the group that completed the olfaction tests, primary procedures were performed in 93 patients (85%), revision procedures in 17 patients (15%), and extended procedures (defined as procedures outside of the confines of the sella) performed in 53 patients (48%).

Of the 110 patients who completed the olfactory study, 91 patients had normal preoperative olfaction and 19 (17%) had mild hyposmia preoperatively (Table 4). Of the patients with normal preoperative function, 5 (5.5%) developed new mild hyposmia, all of whom had rescue flaps performed. No patients developed new postoperative anosmia. Interestingly, of the patients with preoperative hyposmia, 47% had normal olfaction postoperatively. Of the 93 patients who had rescue flaps performed, 79 (85%) had normal olfaction preoperatively and 80 (86%) had normal olfaction postoperatively. Of the 17 patients who had pedicled flaps performed, 12 (71%) had normal olfaction preoperatively and 15 (88%) had normal olfaction postoperatively. Of these 17 patients, only 1 was converted from
rescue flap to NSF. There was no new hyposmia or anosmia in this group.

Amongst rescue flap patients, olfactory function was significantly worse in those with preoperative dysfunction ($P < .01$). Among pedicled flap patients, this did not reach statistical significance ($P = .07$). The 5 patients in the olfactory outcome group with mild hyposmia postoperatively had a higher mean age (62.5 years) compared with those who maintained normal olfaction (51.0 years). All 5 patients in the new hyposmia group had pituitary adenomas resected (4 nonfunctional, 1 prolactinoma), via 3 extended procedures and 1 revision procedure.

There were no instances of postoperative arterial epistaxis that required either endovascular or operative intervention in the full cohort of 165 patients.

**Discussion**

**Surgical Technique**

The use of pedicled NSFs has transformed endoscopic skull base surgery by improving the quality of CSF leak reconstructions associated with extended endonasal approaches to pathology within the subarachnoid space. Overall, NSFs have reduced the incidence of postoperative CSF leak rates from $>20\%$ to $<5\%$ in extended endonasal endoscopic surgery. In most endonasal endoscopic sellar operations, however, either a CSF leak is not encountered (grade 0) or the arachnoid and dural defects are relatively small and can be readily repaired with simpler grafting methods that do not require a flap for the reconstruction (grade 1 and grade 2).

The rescue flap provides a solution to this problem by preserving the arterial pedicle unilaterally without raising a full NSF. If an NSF ultimately became necessary, the rescue flap could be converted without compromising the blood supply. As previously described, the rescue flap had been performed unilaterally with sacrifice of the contralateral arterial pedicle if needed to allow wide surgical access. In addition, the rescue flap eliminates the need to raise an NSF at the beginning of every procedure, thus saving operative time and morbidity while maintaining surgical reconstructive options. The bilateral rescue flap approach allows for preservation of both pedicles and decreases the risk of arterial epistaxis.
We were able to use incisional techniques with preservation of both vascular pedicles and the SOS bilaterally in all of our endonasal endoscopic approaches during the study period (Figure 2A). This was successful in 139 primary operations and 26 reoperations (Table 3), including 87 standard approaches and 78 extended approaches outside of the sella proper. Hence, the most common pituitary lesions can easily be approached with this technique, and recurrent disease does not preclude preservation of these structures. Instrument maneuverability and the ability to perform wide sphenoid exposure were not limited by this approach (Figure 2B).

In our experience, the bilateral rescue flap with mucosal preserving technique was associated with numerous advantages. First, the surgeon is not confined intraoperatively to one side should raising an NSF become necessary. This point is especially important with lateral extension of tumor pathology. Second, by preserving the bilateral nasoseptal vascular pedicles and their main branches, the risk of sphenoopalatine or posterior nasal arterial hemorrhage postoperatively is significantly reduced. In our series, we did not experience a single episode of postoperative arterial episaxis requiring a return to the operating room or embolization. Third, it is our impression that mucosal preservation with subperiosteal dissection results in enhanced long-term healing as well as diminished nasal crusting in the immediate postoperative period. In our series, full mucosalization typically occurred within 6 weeks of surgery, whereas the median reported time to remucosalization following elevation of a formal NSF has been reported to be longer than 12 weeks.21 Finally, given that patients with pituitary pathology will occasionally require reoperations, preservation of the NSF vascular pedicles on both sides allows for multiple potential reconstructive options in future revision operations.

Olfaction

An additional advantage of the mucosal sparing approach is the preservation of the olfactory epithelium along the superior posterior aspect of the nasal septum, a region we defined as the “septal olfactory strip” (SOS). Postoperative olfactory dysfunction, ranging from varying degrees of hyposmia and even complete anosmia, is a well-known complication of transphenoidal surgery (25%-40%).6,22-24 Recent studies have demonstrated that the rate of olfactory dysfunction is somewhat higher in patients undergoing extended approaches and formal NSF elevation (35%-40%).5,9,25

To support the mucosal preservation approach, Sowerby et al26 studied the impact of sacrificing a unilateral middle turbinate and its effect on olfactory and sinonasal outcomes in endoscopic transsphenoidal skull base surgery. They noted that of 22 patients treated, 9 (41%) had a decrease in olfactory function related to sacrificing the middle turbinate unilaterally. Thompson et al27 altered their endonasal approach to preserve the mucosa and limit resection of the middle turbinate, to abandon routine elevation of the nasal septal flap and maxillary antrostomy with an improvement in sinonasal function outcomes.

The precise location of olfactory mucosa in the adult nasal septum is not completely defined and is typically associated with irregular boundaries and patches of respiratory epithelium.28,30 It is generally accepted that olfactory epithelium is present along portions of the superior and middle turbinates, the cribiform plate, and the posterior superior aspect of the nasoseptal mucosa above the horizontal level opposite of the middle turbinate.31-34 In their study, Alobid et al35 suggested that a vertically short olfactory flap may be a factor causing olfactory dysfunction. Dare et al36 found on histologic study that most of the olfactory fibers innervate the nasal septal mucosa, with a lesser amount innervating the superior turbinate and to a lesser degree the middle turbinate. It is therefore at this location on the nasal septum that we perform our nasoseptal mucosal incision separating the SOS from the rescue flap and temporarily elevating it out of our operative field for the duration of the procedure. We preserve the middle and superior turbinates when possible, which was the case in all of our rescue flap cases. It is our belief that these techniques, combined, allow for the least disruption of olfactory tissue and the best possible chance for preservation of olfaction.

Postoperative olfactory outcomes should account for the wide variation in olfactory function encountered in our population (smoking, pollution, nasal allergies) as well as the decrease that occurs with aging. Therefore, we used the B-SIT to evaluate the preoperative and postoperative smell results, which has been validated against the University of Pennsylvania Smell Identification Test.37,38 Our assessment of objective olfaction data in this study group reveals a low rate (5%) of new mild olfactory function dysfunction associated with this technique, lower than reported olfactory dysfunction rates for microscopic and endoscopic transsphenoidal surgical case series.5,25,26,39,40 In patients with normal preoperative olfaction, new dysfunction occurred in 6% of patients, despite preservation of the superior olfactory strip. This new dysfunction could have occurred from surgical manipulation or postoperative inflammation. Conversely, 47% of patients with preoperative olfaction dysfunction (43% in the rescue flap cohort) had improved olfaction after surgery. We surmise this is due to addressing issues such as deviated septa, concha bullosa, sinusitis, and other pathology.

An additional unexpected finding was the preoperative rate of olfactory dysfunction of 17% in our study group, underscoring the need for preoperative smell testing to alleviate causation of the smell dysfunction to the procedure. This study suggests that the preservation of the SOS and middle and superior turbinates results in the preservation of olfactory function in the overwhelming majority of patients. The improved olfactory outcomes in 9 patients who presented with preoperative olfactory dysfunction is most probably related to the improved nasal anatomic functioning due to repair of septal deviations or hyperplastic mucosal disease. Overall, the rescue flap technique netted no difference in pre- and postoperative olfactory function (85% vs 86%). The pedicled NSF cohort did have a net increase in olfactory function (71% vs 88%).


Table 5. Incidence of Postoperative Epistaxis following Endonasal Skull Base Surgery for Pituitary Adenomas and RCCs.

<table>
<thead>
<tr>
<th>Author</th>
<th>Incidence of Delayed Epistaxis, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current study</td>
<td>0</td>
</tr>
<tr>
<td>Berker et al, 2012</td>
<td>0.6</td>
</tr>
<tr>
<td>Messerer et al, 2011</td>
<td>4.9</td>
</tr>
<tr>
<td>Tabaei et al, 2009</td>
<td>3</td>
</tr>
<tr>
<td>Charlalampaki et al, 2009</td>
<td>1.5</td>
</tr>
<tr>
<td>Dehdashi et al, 2008</td>
<td>1</td>
</tr>
<tr>
<td>Cappabianca et al, 2002</td>
<td>1.3</td>
</tr>
<tr>
<td>Harvey et al, 2009</td>
<td>7</td>
</tr>
</tbody>
</table>

Postoperative Epistaxis

The course of the sphenopalatine and posterior nasal arterial branches within the nasal mucosa has been well described previously. Of important note is the consistent location of the NSF arterial pedicle approximately 9 mm inferior to the sphenoid sinus ostium, allowing the surgeon a margin of safety to prevent transection of the pedicle when starting the horizontal mucosal cut at or immediately below the ostium (Figure 1). Postoperative arterial epistaxis has been studied in various publications (Table 5), with an incidence between 0.6% and 7%.

Even when the pedicle is cauterized during a traditional sphenoidotomy, risk of life-threatening arterial epistaxis is an inherent risk. De los Reyes et al reported a 3.3% incidence (18/551 patients) of postoperative epistaxis, with 3 patients repaired operatively and 5 requiring endovascular management. Because of this experience, these authors have now adopted the rescue flap technique described to prevent epistaxis in their center. Thompson et al reported a postoperative epistaxis incidence of 3% (10/330), with 5 patients requiring return to the operating room and 2 patients with new visual field defects due to intrasellar or intrasphenoid blood. This increased risk was maintained comparing endonasal skull base surgery and endoscopic sinus surgery (0.76%-1% in large series). In our study, we did not encounter any patient who required a return to the operating room or postoperative nasal packing due to epistaxis. This may be directly related to the preservation of the posterior sphenopalatine-posterior nasal artery. Therefore, avoiding transection of the SPA-PNA complex is a prudent strategy to prevent potentially life-threatening complications.

Limitations

This study has inherent limitations, as there was no concurrent comparison cohort, given the utilization of rescue flaps as routine at the time of study development. The relative inconsistency in follow-up dates may also have introduced variability in the data analysis. A prospective study comparing both cohorts would be helpful to further elucidate this question. Similarly, it is difficult to discern the preservation of the SOS and middle/superior turbinates when assessing olfaction outcomes. This, too, would benefit from a prospective cohort study for further analysis. In addition, this study did not incorporate patient questionnaire subjective assessments (eg, Sino-nasal Outcome Test–22, Anterior Skull Base Nasal Inventory–12), although the olfaction component of these surveys is limited. Future studies should involve both survey and objective assessments.

Conclusion

The bilateral incisional technique is an effective mucosal-preserving approach that maintains the vascular pedicle of the formal nasal septal flap along with the olfactory epithelium containing the SOS of the posterior superior nasal septum. It is applicable for most endonasal endoscopic operations performed for sellar and parasellar lesions and has the potential to reduce the risk of major or life-threatening postoperative epistaxis originating from the transected sphenopalatine vascular complex, preserve olfaction, and promote rapid nasal mucosal healing, while not hindering exposure or limiting instrument maneuverability. In our study, olfaction was preserved in all patients, with a 5% incidence of mild hyposmia regardless of whether we performed a simple or an extended approach or regardless of the diagnoses or the harvesting of a pedicled flap.

Author Contributions

Chester F. Griffiths, concept/design, data analysis, drafting and editing of manuscript, final approval, accountability; Garni Barkhoudarian, concept/design, data analysis, drafting and editing of manuscript, final approval, accountability; Aaron Cutler, concept/design, data analysis, drafting and editing of manuscript, final approval, accountability; Huy T. Duong, concept, data analysis, editing of manuscript, final approval, accountability; Olivia Doyle, data analysis, review and editing of manuscript, final approval, accountability; Ricardo Carrau, data analysis, editing of manuscript, final approval, accountability; Daniel F. Kelly, data analysis, editing of manuscript, final approval, accountability.

Disclosures

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